‘ULU MAIKA, WORK, AND POWER!

BY ROBERTO CASTRO

Why were Makahiki games such as Ulu Maika so important to the Hawaiian of Old? Do you think that Work and Power could be used as a parameter for Ulu Maika game rules?

MIDDLE SCHOOL EIGHTH GRADE

TIMEFRAME THREE SESSIONS - 50 MIN. EACH

STANDARD BENCHMARKS AND VALUES

- The availability of energy limits what can occur in any system. (HS-PS3-1)
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4)
- Students will explore how the rate at which work is done is dependent on time when Work is a fixed value.
- Students will demonstrate skill and compare their power with classmates through the ancient skill game of ‘ulu maika.
ENDURING UNDERSTANDING
1. Energy makes things go!
2. Hawaiians of Old understood Energy and Power so they made games like ‘Ulu Maika to demonstrate their skill and power.
3. Work is the change in energy AND force times distance.
4. Power is how fast Work is done (Work/time).

CRITICAL SKILLS AND CONCEPTS
- Students will be able to calculate work and power.
- Students will be able to apply the work and power concepts and equations to a real life situation.
- Students will be able to differentiate which variables apply to which function (ex: rolling distance, rolling time, swinging distance, swinging time).
- Students will be able to connect previous learned skills and see how other quantities (force, acceleration, speed, distance, and time) relate to energy, work, and power.

AUTHENTIC PERFORMANCE TASK:
- Students will show that they deeply understand the concepts of work and power by calculating their Power during a match of ‘ulu maika.
- Students will recall the equations for Power, Work, Force, Acceleration, and speed and apply these concepts to calculate their delivery and rate of Energy transfer.

AUTHENTIC AUDIENCE:
Students will have their efforts evaluated by the teacher. As part of this activity will be required to report their findings in a graphical format, showing how the time of a students’ swinging the stone will impact. Students are going to be required to present their results to their parents and share ‘ulu maika and the process to find work and power. A reflection will be required at the end of the unit to evaluate student effort to expand the knowledge learned outside of the classroom.

OTHER EVIDENCE:
- Calculations & Application
- Work Samples
- Activity Results
LEARNING PLAN

TOPIC INTRODUCTION:
Teacher must introduce the ancient game of ‘ulu maika by probing students’ prior knowledge of the game. Discuss parallel cultural practices with modern games and relevance to subject taught.

BEGIN INSTRUCTION:
Teach students how to calculate a problem with the guided notes worksheet titled: ‘Ulu Maika Power! Follow the 8 steps and allow students to practice the 8 steps with the Examples worksheet with Jo, Mo, & Fro.

OPTIONAL FINAL ASSESSMENT:
Measure student mastery of the concept with “The Bowling Quiz” Worksheet. As a final assessment an applied lab is recommended at the bowling alley after having discussed with the class the parallel application of work and power with ‘ulu maika and bowling.

CONCEPT APPLICATION:
‘Ulu Maika: The Physics of Makahiki Games WS.
Students will apply learned concepts by playing two matches of ‘ulu maika with two different masses and two different rolling distances.

To do so students will find the values of the following variables:
1. Swing distance - horizontal distance from point of release to furthest horizontal swing position.
2. Swing time - time of swing (from furthest position to time of release).
3. Rolling distance - Distance between point of release and stakes.
4. Roll time - Time it takes for the stone to roll from release point to the stakes.
5. Weight of the ‘ulu - Weight of the ball in pounds.

MATERIALS NEEDED:
- Weighted disc (‘ulu)
- Tape Measurers
- Calculators
- Timers
- Pegs
THE EIGHT STEPS

STEP ONE
IDENTIFY THE VALUES OF THE FOLLOWING VARIABLE:
1. Swing distance
2. Swing time
3. Rolling distance
4. Rolling time
5. Weight of the ball

STEP TWO
CALCULATE THE SPEED OF THE ‘ULU AS IT ROLLS
\[ v = \frac{\text{rolling distance}}{\text{rolling time}} \]
units: meters / second

STEP THREE
DETERMINE INITIAL SPEED AND FINAL SPEED DURING SWING OF THE ‘ULU
1. Initial velocity during the swing will always be 0 m/s.
2. Final velocity during the swing will be the rolling speed.

STEP FOUR
CALCULATE ACCELERATION OF THE ‘ULU CAUSED BY THE SWING
\[ a = \frac{(\text{final velocity} - \text{initial velocity})}{(\text{swing time})} \]
units: meters / second

STEP FIVE
WEIGH ‘ULU & CALCULATE MASS OF THE ‘ULU
\[ \text{Mass} = \frac{\text{weight of the ‘ulu}}{2.2} \]
units: kilograms

STEP SIX
CALCULATE FORCE EXERTED ONTO THE ‘ULU
\[ \text{Force} = \text{mass} \times \text{acceleration} \]
units: Newtons

STEP SEVEN
CALCULATE THE WORK DONE ON THE ‘ULU DURING THE SWING
\[ W = \text{FORCE} \times \text{SWING DISTANCE} \]
units: Joules

STEP EIGHT
CALCULATE THE POWER APPLIED DURING THE SWING
\[ \text{Power} = \frac{\text{Work}}{\text{Swing time}} \]
units: Watts
INTRODUCTION READINGS TO ‘ULU MAIKA

Early Hawaiians devoted large amounts of time to games, amusements, and relaxing pastimes. Games were played to develop strength, endurance, and skills. ‘Ulu maika (or ‘olohu), one of the most popular sports in early Hawai‘i, is an example a skill game where competitors roll stones towards two stakes, the victor decided upon by a variety of criteria (proximity to stakes, furthest thrown, etc.) In early Hawai‘i only men were allowed to roll the stone disks, ‘ulu, between stakes to test their skill or down long courses, free of stakes, to show their strength. Even to this day the sport is played, as hundreds of the skillfully fashioned stones of the era existing in museums and private collections. Unfortunately, many kahua maika (specially prepared courses on which the stones were rolled) used in the days of the early Hawaiians have been destroyed.

The School and University Partnership for Educational Renewal in Mathematics
An NSF-funded Graduate STEM Fellows in K–12 Education Project
University of Hawai‘i at Manoa, Department of Mathematics

‘ULU MAIKA

Rolling Stone Disks

A playfield with close-cut grass or smooth firm soil

‘Ulu maika or ‘olohu was one of the most popular sports in early Hawai‘i. Hundreds of the skillfully fashioned playing stones used in those days, which may be called either ‘ulu or maika, still exist in museums and private collections. Many kahua maika (specially prepared courses on which the stones were rolled) were in use in earlier times. Unfortunately most of these have been destroyed.

One of the best of the remaining maika courses, some five hundred yards long, is at Kalama‘ula, Moloka‘i. A great deal of excavation was done on this course to provide the proper grade for the track and the cup-like sides that would direct a stone back to the bottom if it rolled out of line.

In early Hawai‘i only men were allowed to roll the stone disks between stakes to test their skill, or down long courses, free of stakes, to show their strength. This game would develop the arm and leg muscles of the players as well as their skill in handling the stone disks.

Hawaiian Games to Play
(Second Edition)
Donald D. Kilolani Mitchell

5 Ethnomathematics
‘ULU MAIKA POWER

I. IMPORTANT EQUATIONS:  
1. Power =  
2. Work =  
3. Force =  
4. Acceleration =  
5. Speed =

II. IMPORTANT UNITS:  
1. Power ________  
2. Work ________  
3. Force ________  
4. Distance ________  
5. Speed ________  
6. Time ________  
7. Acceleration ________

III. THE SITUATION:  
Ho’olu picks up an ‘ulu maika disk that weighs 14 lbs. He positions himself 18 meters away from the stakes to begin his throw. Ho’olu swings the disk through a distance of 3 meters from the beginning of his swing to the point of release. His swing takes 1.4 seconds. The disk rolls down for 3 seconds and it goes right through the wooden stakes!

IV. FILL IN THE BLANKS WITH THE CORRECT VALES (DON’T FORGET UNITS!):  
Weight of ‘ulu: __________

point of release

wooden stakes

Swinging d: ______
Swinging t: ______
Rolling d: ______
Rolling t: ______
V. EIGHT STEPS TO DETERMINE HO‘OLU’S POWER!

STEP ONE: Make sure all needed data is known.
Do you know the...
Swinging distance? _______ Rolling time? _______ Weight of the ‘ulu? _______
Swinging time? _______ Rolling distance? _______

STEP TWO:
Calculate the ______________________ of the ‘ulu as it ______________________ towards the stakes.

\[ V_{roll} = \] _______ _______ _______ _______ _______ _______ _______

STEP THREE:
Determine the __________ speed (\( v \)) and the __________ speed (\( v_i \)) of the ‘ulu during the __________ (hand back to the release).

\[ v_i = \] _______ _______ _______ _______ _______ _______ _______
\[ v_f = \] same as _______ _______ _______ _______ _______ _______

STEP FOUR:
Calculate the ________________ of the ‘ulu during the ______________________.

\[ a = \] _______ _______ _______ _______ _______ _______ _______

STEP FIVE:
Calculate the ________________ of the ‘ulu.

\[ m = \] _______ _______ _______ _______ _______ _______ _______

STEP SIX:
Calculate the ________________ of the player uses when ______________________ the ‘ulu.

\[ \text{(Newton’s ______ Law)} \quad F = ( ) ( ) = ( ) ( ) = \] _______ _______ _______ _______ _______ _______ _______

STEP SEVEN:
Calculate the work done on the ________________ during the ______________________.

\[ W = ( ) ( ) = ( ) ( ) = \] _______ _______ _______ _______ _______ _______ _______

STEP SEVEN:
Calculate the ________________ used by the ______________________!

\[ P = \] _______ _______ _______ _______ _______ _______ _______
‘ULU MAIKA POWER
ANSWER SHEET

I. IMPORTANT EQUATIONS:
1. Power \( P = \frac{\text{Work}}{\text{time}} \)
2. Work \( W = F \times d \)
3. Force \( F = m \times a \)
4. Acceleration \( a = \frac{v_f - v_i}{t} \)
5. Speed \( v = \frac{d}{t} \)

II. IMPORTANT UNITS:
1. Power \( \text{Watts (W)} \)
2. Work \( \text{Joules (J)} \)
3. Force \( \text{Newtons (N)} \)
4. Distance \( \text{meters (m)} \)
5. Speed \( \frac{\text{meters}}{\text{seconds}} = (\text{m/s}) \)
6. Time \( \text{seconds (s)} \)
7. Acceleration \( \frac{\text{meters}}{\text{seconds}^2} = (\text{m/s}^2) \)

III. THE SITUATION:
Ho’olu picks up an ‘ulu maika disk that weighs 14 lbs. He positions himself 18 meters away from the stakes to begin his throw. Ho’olu swings the disk through a distance of 3 meters from the beginning of his swing to the point of release. His swing takes 1.4 seconds. The disk rolls down for 3 seconds and it goes right through the wooden stakes!

IV. FILL IN THE BLANKS WITH THE CORRECT VALES (DON’T FORGET UNITS!):

Weight of ‘ulu: \( 14 \text{ lbs.} \)

Swinging d: \( 3 \text{ m} \)
Swinging t: \( 1.4 \text{ s} \)
Rolling d: \( 18 \text{ m} \)
Rolling t: \( 3 \text{ s} \)

‘Ulu Maika, Work, and Power 8
V. EIGHT STEPS TO DETERMINE HO'OLU'S POWER!

STEP ONE: Make sure all needed data is known.
Do you know the ...
Swinging distance?  **3 m**  Rolling time?  **18 m**  Weight of the 'ulu?  **14 lbs**
Swinging time?  **1.4 s**  Rolling distance?  **3 s**

STEP TWO:
Calculate the ________ speed ________ of the 'ulu as it ________ rolls ________ towards the stakes.
\[
\mathbf{v}_{\text{roll}} = \frac{\text{distance}}{\text{time}} = \frac{18 \text{ m}}{3 \text{ s}} = 6 \text{ m/s}
\]

STEP THREE:
Determine the ________ initial ________ speed (v_i) and the ________ final ________ speed (v_f) of the 'ulu during the ________ swing ________ (hand back to the release).
\[
v_i = 0 \quad \quad \quad v_f = 0
\]

STEP FOUR:
Calculate the ________ acceleration ________ of the 'ulu during the ________ swing ________.
\[
a = \frac{v_i - v_f}{\text{swing time}} = \frac{6 \text{ m/s} - 0 \text{ m/s}}{1.4 \text{ s}} = 4.3 \text{ m/s}^2
\]

STEP FIVE:
Calculate the ________ mass ________ of the 'ulu.
\[
m = \frac{\text{weight in pounds}}{2.2} = \frac{14 \text{ lbs}}{2.2} = 6.36 \text{ kg}
\]

STEP SIX:
Calculate the ________ force ________ of the player uses when ________ swinging ________ the 'ulu.
\[
\text{Newton's 2}^{\text{nd}} \text{ Law} \quad \quad \quad F = (m)(a) = (6.36 \text{ kg})(4.3 \text{ m/s}^2) = 27.36 \text{ N}
\]

STEP SEVEN:
Calculate the work done on the ________ 'ulu ________ during the ________ swing ________.
\[
W = (F)(\text{swing d}) = (27.36 \text{ N})(3 \text{ m}) = 82.08 \text{ J}
\]

STEP SEVEN:
Calculate the ________ power ________ used by the ________ player’s swing ________!
\[
P = \frac{\text{work}}{\text{swing time}} = \frac{82.08 \text{ J}}{1.4 \text{ s}} = 58.63 \text{ W}
\]
BOWLING LAB!

OBJECTIVE: SWBAT calculate their bowling power and relate variables with their output power!

HYPOTHESIS: Using your ‘ulu maika calculations make an informed prediction as to what your bowling power will be.

“I predict that I will bowl with a power of _______________ Watts!”

MATERIALS:
- Bowling ball
- 2 Timers
- Tape measurer

Step 1. Gather the data:
- Weight of Bowling ball
- Swing distance
- Swing time
- Roll distance
- Roll time

CALCULATIONS:

Step 2.
\[ V_{roll} = \frac{\text{rolling distance}}{\text{rolling time}} \]

Step 3.
\[ V_f = \quad V_i = \]

Step 4.
\[ \text{acceleration} = \frac{V_f - V_i}{\text{swing time}} \]

Step 5.
\[ \text{mass} = \frac{\text{weight of the ball}}{2.2} \]

Step 6.
\[ F = m \times a \]

Step 7.
\[ \text{Work} = F \times \text{Swing Distance} \]

Step 8.
\[ \text{Power} = \frac{\text{work}}{\text{swing time}} \]

Last Step.
\[ \text{Percentage Error} = \frac{\text{prediction} - \text{actual}}{\text{actual}} \times 100\% \]

Analyze the data.
DISCUSSION.

1. Were you able to calculate your Power while bowling? Was your prediction too low, too high, close or correct? (Mention your percentage error.)

2. Which variables (swing t, roll t, roll d, swing d) contributed the most for greater power? What could you do to increase your power?

3. Who was the most powerful in your team? Which variable helped the most powerful in your team?

4. If ancient Hawaiians used Power to decide ‘ulu maika winners, what could they have used as measuring instruments?

5. Did you like the bowling lab? What would you do differently?
Mambo picks up a 13 lb. ball and swings it at a distance of 3 meters in 1.1 seconds. The ball makes contact with the floor and rolls 18 meters in 2.2 seconds. What is Mambo’s power?
OBJECTION: Students will demonstrate skill and compare their power with classmates through the ancient skill game of ‘ulu maika.

Choose 2 GLO’s relevant to the topic:

Choose 2 HOM’s relevant to the topic:

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TEAM MEMBERS</th>
<th>INSTRUCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• stakes</td>
<td>1. __________</td>
<td>1. Select two fields and two ‘ulu weights</td>
</tr>
<tr>
<td>• ‘ulu-disk</td>
<td>2. __________</td>
<td>2. Assign who in your team will measure your swing time, roll time, and your swing distance.</td>
</tr>
<tr>
<td>• timers</td>
<td>3. __________</td>
<td></td>
</tr>
<tr>
<td>• tape measurer</td>
<td>4. __________</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. __________</td>
<td></td>
</tr>
</tbody>
</table>

1. Calculate your power on the first field set.

Step 1. 
- swinging distance: 
- rolling distance: 
- weight of the ‘ulu: 

Step 2. Calculate the rolling speed

\[ v_{roll} = \] 

\[ = \] 

\[ = \]
Step 3. Identify initial and final velocity.

\[ v_i = \quad v_f = \]

Step 4. Calculate acceleration of ‘ulu during the swing.

\[ \text{acceleration} = \quad = \quad = \]

Step 5. Calculate the mass of the ‘ulu.

\[ \text{mass} = \quad = \quad = \]

Step 6. Calculate the force during the swing.

\[ \text{Force} = ( \quad ) \cdot ( \quad ) = ( \quad ) \cdot ( \quad ) = \]

Step 7. Calculate the work done by the ‘ulu as it rolls towards the stakes.

\[ W = ( \quad ) \cdot ( \quad ) = ( \quad ) \cdot ( \quad ) = \]

Step 8. Calculate the power during the swing.

\[ P = \quad = \quad = \]

II. Calculate your power on the second field set.

Step 1. swinging distance:

rolling distance:

weight of the ‘ulu:

swinging time:

rolling time:
FIND THE POWER OF THE ‘ULU MAIKA
The Physics of Makahiki Games

1.) Find the power of Jo by following the eight steps - Show your work.

Step 1.
| swinging distance: | swinging time: |
| rolling distance:  | rolling time:  |
| weight of the ‘ulu:|                          |

Step 2.
Speed =

Step 3.
\[ v_i = \quad v_f = \]

Step 4.
Acceleration =

Step 5.
mass =

Step 6.
force =

Step 7.
work =

Step 8.
power =
2.) Find the power of Mo.

Mo

\[
\begin{array}{c}
\text{4 m} \\
\text{time: 1.5 sec}
\end{array}
\quad \begin{array}{c}
\text{18 m} \\
\text{time: 5 sec}
\end{array}
\]\n
\[
\begin{array}{c}
\text{swinging d:} \\
\text{swinging t:} \\
\text{rolling d:} \\
\text{rolling t:} \\
\text{weight:}
\end{array}
\]

<table>
<thead>
<tr>
<th>Step 1.</th>
<th>swinging d:</th>
<th>swinging t:</th>
<th>rolling d:</th>
<th>rolling t:</th>
<th>weight:</th>
</tr>
</thead>
</table>

Step 2.

Step 3.

Step 4.

Step 5.

3.) Find the power of Fro.

Fro

\[
\begin{array}{c}
\text{2 m} \\
\text{time: 9 sec}
\end{array}
\quad \begin{array}{c}
\text{18 m} \\
\text{time: 3 sec}
\end{array}
\]\n
\[
\begin{array}{c}
\text{swinging d:} \\
\text{swinging t:} \\
\text{rolling d:} \\
\text{rolling t:} \\
\text{weight:}
\end{array}
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Step 2.

Step 3.

Step 4.

Step 5.

Step 6.

Step 7.

Step 8.